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FISKE FUND PRIZE DISSERTATION. NO. LII

The Mode of Infection

AND

Duration of the Infectious Period

IN

Scarlet Fever.

MOTTO:

Dextrae se nostra Scientia
Implicuit, sequiturque Verum non passibus aequis.

BY
CHARLES V. CHAPIN, M. D.,
PROVIDENCE, R. I.

Columbia University
in the City of New York

College of Physicians and Surgeons

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PROVIDENCE:
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THE Trustees of the Fiske Fund, at the annual meeting of the Rhode Island Medical Society, held at Providence, June 1, 1909, announced that they had awarded a premium of two hundred ($200) to an essay on "The Mode of Infection and Duration of the Infectious Period in Scarlet Fever," bearing the motto :

"Dextrae se nostra Scientia
Implicuit, sequiturque Verum non passibus aequis."

The author was found to be CHARLES V. CHAPIN, M. D., of Providence, R. I.

DR. FRANK B. FULLER, Providence,
DR. EUGENE KINGMAN, "
DR. A. A. MANN, Central Falls,
Trustees.

HALSEY DEWOLF, M. D., Providence,
Secretary of the Trustees.

The Mode of Infection and Duration of the Infectious Period in Scarlet Fever.

It is much to be regretted that the specific organism which is doubtless the cause of scarlet fever has not as yet been identified. Various observers have from time to time, described cocci, or bacilli, which they believed, or suspected to be, the cause of the disease. Klein isolated a diplococcus which for a while was thought by many to be the specific germ, but his observations have not stood the test of time, and neither have those of Class, who later also reported a diplococcus as the *vera causa*. More recently Mallory (1) described certain bodies in the skin of scarlet fever patients which he believed to be protozoa, and which he suspected might stand in causative relation to the disease, and within a few months Gamaleia (2) has also reported finding protozoan forms constantly present. The findings of these last two observers have not as yet been verified. At present therefore we can only employ clinical or epidemiological methods, in the investigation of scarlet fever, and such methods are difficult, and by themselves are unlikely to yield decisive results.

Before proceeding to the discussion of the subject, it is perhaps well to call attention to the analogy which has been supposed to exist between scarlet fever and smallpox. There is a good deal of desquamation, as well as shedding of the crusts, in smallpox, and these crusts, and presumably the epidermis also, are infectious. The desquamation in scarlet fever has been believed to be similar in nature to that of smallpox, due to the active working of the specific poison in the skin, and therefore also infectious.

A more careful study of scarlet fever has led many to see that this resemblance is superficial merely, and that scarlet fever seems to be much more like diphtheria than any other disease. The age incidence of the two diseases is about the same, as is also the degree of infectivity. The period of incubation is nearly the same. A long latent period may often be noted in each. Both diseases begin with sore throat, and the throat symptoms are usually the most prominent symptoms, and are so nearly alike in the two diseases that except for the rash in the one case, and the finding of diphtheria bacilli in the other, it is difficult in most cases to make a diagnosis. In fact many cases of scarlet fever are before the appearance of the rash, considered to be diphtheria. In both diseases albuminuria and middle ear inflamation are common. Both diseases are infectious at the very beginning, and the infectivity gradually disappears in a few weeks, but in

some instances may be retained for months, and often this infectivity seems to be connected with a chronic rhinitis. Scarlet fever seems to be as much a local disease of the throat as is diphtheria. The eruption in scarlet fever appears much more likely to be the result of a toxemia, than to an actual invasion of the skin by the parasite, as is the case in smallpox.

It will be more convenient to consider the duration of infectivity first, and modes of infection afterwards, and as a preliminary step we may inquire as to the duration of incubation, for without some knowledge of this, it is difficult to determine what period of the disease is infectious.

The word incubation as here used, merely means the time which elapses between the implantation of the infectious material and the development of the initial symptoms. It is true, incubation carries with it the idea that the virus of the disease must of necessity have a more or less definite interval in which to multiply and perhaps pass through a certain portion of a more or less complicated life cycle. But in a number of infectious diseases, such as diphtheria, it is known with a fair degree of certainty that this is not so. In some cases as soon as diphtheria bacilli are planted on a mucous surface they begin to proliferate and produce toxins, and probably if our vision were acute enough could be seen to cause tissue changes within a remarkably short time. Certainly quite marked pathological

conditions are sometimes noticeable in a few hours. This has particularly been the case in those laboratory infections where the moment of implantation was known, and where the symptoms were carefully watched.

According to most observers the incubation of scarlet fever is usually short, in most instances a few days only. A committee of the Boston Society of Medical Improvement, appointed to consider the subject, reported (3) that the period of incubation in scarlet fever is as a rule two or three days, but may be extended to eight days, and possibly twenty (McCollom). Reference is made by the above committee to Murchison (4) who collected reports of 75 cases in which the period of incubation in 73 could not have been over 5 days, in 54 it could not have been over 4 days, in 20 not over 3 days, in 15 not over 2 days, and in three instances it could not have exceeded 24 hours. The committee quote from a dozen or more writers whose observations and opinions are in entire accord with Murchison's. Thus Reimer found that in two thirds of 3,624 cases the disease developed within the first three days after exposure.

The writer's experience has led him to concur in the conclusions as stated above, that is, that the period of incubation is usually only a few days, and that it may be only a few hours. This conclusion is based upon First; the time when secondary cases develop in the family. Second; the time when other families in the

same house develop the disease. Third; the time when cases develop in the family after return from the hospital. Fourth; the time when well children sent away from home sicken with the disease while away or after their return, and Fifth; a few special instances. Tables illustrating the first two points are given on pages 12 and 13.

Hospital return cases from my own experience are not very numerous, but the facts correspond with the English data given by Cameron and Turner. In the latter's experience 441 of 1,129 "return cases" of scarlet fever occurred in the first week. Of my own 41 observed cases 23 were in the first week after return. Of 52 well persons who were removed from scarlet fever houses under my observation, and who were afterwards taken sick, 29 developed the disease during the first week.

While it is possible that in the majority of cases of scarlet fever the period of incubation is only a few days, it may be prolonged perhaps for weeks. We know that the period of incubation is usually short in diphtheria, but that sometimes a person may harbor diphtheria bacilli in throat or nose for weeks, and yet remain perfectly well, and then finally the disease will develop. It is probable that precisely the same thing happens in scarlet fever. Welch and Schamberg (5) quote Hagenbach-Burchhardt and Holt as reporting many cases of prolonged incubation some extending as

long as 21 days. It is probable that from a pathological standpoint, incubation in scarlet fever has little meaning. The fact that cases returning from a hospital may be slow in infecting the family, or that well members of the family returning home after the termination of isolation, may not quickly develop the disease, probably means that in these instances the virus of the disease is small in amount, or is not thrown off continuously from the infecting case. Thus an intermittently discharging ear would readily explain cases of delayed infection or what would apparently be prolonged incubation.

DURATION OF THE INFECTIOUS PERIOD.

There is much evidence to show that scarlet fever is infectious in the early stages, particularly during the height of the throat symptoms. A considerable number of cases are on record where a person exposed to scarlet fever during this period contracted the disease. Several of these are mentioned on pages 23 and 25 of this essay. This evidence from individual cases is also in accord with much statistical evidence. The following tables prepared by the writer show,

First, The time at which secondary infections occur in the family.

Second, The time at which other families in the house become infected.

These tables indicate that in a large proportion of the families the infection of others takes place during the first week of the disease. This would scarcely be possible unless the period of incubation was short and the disease infectious in the early stages.

TABLE I. SCARLET FEVER.

Day of Initial Sickness on which Secondary Cases Occurred.

Second Cases.						Third and Later Cases.						All Cases Subsequent to Primary.					
Day of Initial Sickness.	Number of Cases.	Per cent.	Day of Initial Sickness.	Number of Cases.	Per cent.	Day of Initial Sickness.	Number of Cases.	Per cent.	Day of Initial Sickness.	Number of Cases.	Per cent.	Day of Initial Sickness.	Number of Cases.	Per cent.	Day of Initial Sickness.	Number of Cases.	Per cent.
1	67	9.76	38	2	.29	1	6	1.39	38	2	.46	1	73	6.54	38	4	.36
2	77	11.22	39	2	.29	2	15	3.48	39	2	.46	2	92	8.24	39	4	.36
3	67	9.76	40	1	.15	3	16	3.72	40	2	.46	3	83	7.43	40	3	.27
4	42	6.12	41	1	.15	4	13	3.02	41	2	.46	4	55	4.92	41	3	.27
5	46	6.70	42	1	.15	5	22	5.11	42	1	.23	5	68	6.09	42	2	.18
6	42	6.12	43	.....	.....	6	36	8.36	43	.....	.....	6	78	6.98	43	.....	.....
7	32	4.66	44	1	.15	7	18	4.18	44	.....	.....	7	50	4.48	44	1	.08
8	39	5.69	45	2	.29	8	11	2.55	45	1	.23	8	50	4.48	45	3	.27
9	30	4.37	46	2	.29	9	15	3.48	46	4	.93	9	45	4.03	46	6	.54
10	26	3.79	47	5	.73	10	18	4.18	47	2	.46	10	44	3.94	47	7	.63
11	18	2.62	48	2	.29	11	20	4.64	48	2	.46	11	38	3.40	48	4	.36
12	16	2.33	49	.....	.....	12	18	4.18	49	.....	.....	12	34	3.04	49	.....	.....
13	6	.87	50	1	.15	13	17	3.95	50	.....	.....	13	23	2.06	50	1	.08
14	13	1.90	51	.....	.....	14	20	4.64	51	2	.46	14	33	2.95	51	2	.18
15	18	2.62	52	.....	.....	15	12	2.78	52	.....	.....	15	30	2.69	52	.....	.....
16	13	1.90	53	.....	.....	16	10	2.32	53	.....	.....	16	23	2.06	53	.....	.....
17	8	1.17	54	.....	.....	17	14	3.25	54	1	.23	17	22	1.97	54	1	.08
18	8	1.17	55	1	.15	18	12	2.79	55	.....	.....	18	20	1.79	55	1	.08
19	11	1.60	56	2	.29	19	16	3.72	56	1	.23	19	27	2.42	56	3	.27
20	12	1.75	9th wk.	5	.73	20	6	1.39	9th wk.	1	.23	20	18	1.61	9th wk.	6	.54
21	8	1.17	10th "	4	.58	21	10	2.32	10th "	1	.23	21	18	1.61	10th "	5	.45
22	7	1.02	11th "	3	.44	22	6	1.39	11th "	5	1.16	22	13	1.17	11th "	8	.72
23	5	.73	12th "	4	.58	23	6	1.39	12th "	1	.23	23	11	.99	12th "	5	.45
24	1	.14	13th "	2	.29	24	7	1.63	13th "	4	.93	24	8	.72	13th "	6	.54
25	7	1.02	14th "	.....	.....	25	5	1.16	14th "	.....	.....	25	12	1.08	14th "	.....	.....
26	3	.44	15th "	1	.15	26	6	1.39	15th "	.....	.....	26	9	.81	15th "	1	.08
27	3	.44	16th "	.....	.....	27	6	1.39	16th "	1	.23	27	9	.81	16th "	1	.08
28	2	.29	17th "	1	.15	28	1	.23	19th "	1	.23	28	3	.27	17th "	1	.08
29	4	.58	.....	.....	.....	29	8	1.86	24th "	1	.23	29	12	1.08	19th "	1	.08
30	3	.44	.....	.....	.....	30	4	.93	.....	.....	.....	30	7	.63	24th "	1	.08
31	3	.44	.....	.....	.....	31	4	.93	.....	.....	.....	31	7	.63	.....	.....	.....
32	1	.15	.....	.....	.....	32	6	1.39	.....	.....	.....	32	7	.63	.....	.....	.....
33	.....	.....	.....	.....	.....	33	1	.23	.....	.....	.....	33	1	.08	.....	.....	.....
34	1	.14	.....	.....	.....	34	3	.70	.....	.....	.....	34	4	.36	.....	.....	.....
35	2	.29	.....	.....	.....	35	1	.23	.....	.....	.....	35	3	.27	.....	.....	.....
36	1	.15	.....	.....	.....	36	4	.93	.....	.....	.....	36	5	.45	.....	.....	.....
37	1	.15	.....	.....	.....	37	1	.23	.....	.....	.....	37	2	.18	.....	.....	.....
				686	100.00					431	100.00					1,117	100.00

TABLE II. SCARLET FEVER.

Time of Infection of Other Families in House.

During Period of Isolation of First Sickness.				After Termination of Isolation.							
				Day of Initial Sickness.				Day of Release from Isolation.			
Day of Initial Sickness.	Number of Cases.	Day of Initial Sickness.	Number of Cases.	Day.	Case.	Day.	Case.	Day.	Number of Cases.	Day.	Number of Cases.
1	9	38	1	1	....	38	....	1	1	38	....
2	6	39	....	2	....	39	1	2	1	39	....
3	6	40	....	3	....	40	....	3	....	40	1
4	3	41	1	4	....	41	....	4	1	41	....
5	7	42	2	5	....	42	....	5	....	42	....
6	4	43	....	6	....	43	1	6	....	43	....
7	2	44	1	7	....	44	....	7	....	44	....
8	4	45	....	8	....	45	....	8	....	45	....
9	2	46	....	9	....	46	....	9	1	46	....
10	1	47	....	10	....	47	1	10	3	47	....
11	1	48	1	11	....	48	....	11	....	48	....
12	3	49	....	12	....	49	2	12	....	49	....
13	4	50	....	13	....	50	....	13	....	50	1
14	2	51	....	14	....	51	....	14	....	51	....
15	....	52	1	15	....	52	....	15	....	52	1
16	....	53	1	16	....	53	....	16	....	53	1
17	1	54	1	17	....	54	....	17	2	54	....
18	....	55	....	18	....	55	2	18	....	55	....
19	....	56	....	19	....	56	....	19	....	56	....
20	1	57	....	20	2	57	1	20	....	57	....
21	....	58	....	21	....	58	....	21	1	58	1
22	1	59	....	22	....	59	1	22	....	59	....
23	....	60	1	23	....	60	1	23	....	60	....
24	1	3rd mo.	2	24	....	3rd mo.	11	24	1	3rd mo.	8
25	1	4th "	....	25	....	4th "	6	25	....	4th "	2
26	1	5th "	....	26	....	5th "	....	26	....	5th "	....
27	....	6th "	....	27	....	6th "	1	27	....	6th "	2
28	2	7th "	....	28	....	7th "	3	28	1	7th "	3
29	1	8th "	....	29	....	8th "	1	29	1	8th "	....
30	2	9th "	....	30	....	9th "	....	30	1	9th "	....
31	....	10th "	....	31	1	10th "	....	31	....	10th "	1
32	....	11th "	....	32	....	11th "	1	32	1	11th "	....
33	....	12th "	....	33	....	12th "	....	33	....	12th "	1
34	....	.....	....	34	....	13th "	1	34	....	.....	....
35	2	.....	....	35	1	.....	....	35	....	.....	....
36	1	.....	....	36	....	.....	....	36	....	.....	....
37	....	.....	....	37	....	.....	....	37	1	.....	....
			80				38				38

That the infectivity is at its height during the early days of the disease, and that it diminishes quite rapidly after the disappearance of the throat symptoms and the rash, also seems to be indicated by the data just given. This however is contrary to the popular notion, for most of the laity, and many physicians, consider that scarlet fever is much more infectious during desquamation than at any other time. As will be shown when discussing the infectiousness of the exfoliated epidermis there does not appear to be any experimental or clinical evidence of this. Yet it must be admitted that while the facts of rapidly diminishing extension of the disease in and out of the family, is in accord with the view that the infectivity also rapidly diminishes after the disappearance of the acute symptoms, it is not a proof of it, for the decreasing number of cases in the family may be due to the using up of all susceptible material, and failure to extend beyond the family may be due, in part, as seems to the writer probable, to the success of the isolation which is enforced as soon as the cases are recognized. But surely there is nothing in these facts to indicate a greater degree of infectiousness during the later than during the earlier stages of the disease.

The following facts do indicate quite clearly the diminishing infectivity during the later stages. I have records of the removal of 493 well children from families where there was scarlet fever, showing the

time at which they returned. Unfortunately I made no record of cases that returned home within a week, but probably these would have shown an equal or even higher incidence of the disease.

	Number of Weeks Away.							Over	Un-	Total
	1	2	3	4	5	6	7	7	known.	Children.
Children who were attacked on return....	7	5	5	5	2	0	0	0	0	24
Children who were not attacked on return..	20	29	86	87	126	74	18	21	8	469

The rapidly diminishing infectivity of the disease is plainly shown by these figures. It is well known that the specific bacilli not rarely disappear from cases of diphtheria within a week or ten days of the onset of the disease. In my own city only 1.8 per cent of the cases retain their infection for ten weeks or more. The various data that have been presented concerning scarlet fever indicate that the infectivity of this disease also disappears in much the same way, as does that of diphtheria. Barlow (6) and Zilgien (7) have recently considered this subject, and believe that in view of all the facts, we are justified in assuming that in a large number of mild cases of scarlet fever, the infectivity disappears by the end of the third week.

Unfortunately we have no means of determining in this disease as we have in diphtheria, the cases in which this happens. An arbitrary time limit has to

be fixed for the minimum period of isolation in scarlet fever. In the majority of cities this is fixed at six weeks, and in some English cities at seven or eight weeks, but in certain American cities it is much less. Thus it is, or was for many years, five weeks in Rochester, four weeks in Brookline, Mass., Concord, N. H., Newton, Mass., Kansas City and Omaha, and three weeks in Buffalo, Cambridge, Grand Rapids, Holyoke, Lowell, Minneapolis, Newark, New York City, Syracuse and Utica. Scarlet fever is even more prevalent in English cities than it is in the cities of the United States, and a study of the disease in the latter country does not indicate that the cities which maintain a longer period of isolation have an appreciably less amount of disease than do those with a shorter period. In Providence the period of isolation was shortened from five to four weeks without noticeable change in the prevalence of the disease. It is indeed true that nearly always the minimum period of isolation is exceeded if desquamation continues, but as will be seen, it is probable that the exfoliated epidermis is not infectious. It is fair to infer from these facts that the infectivity of scarlet fever in its later stages is not very great.

It is certain however that a small number of cases remain infectious for a very long time, just as some cases of diphtheria may remain carriers of the bacilli for many weeks or months, and it seems probable that this late infectivity in scarlet fever is somewhat more

prolonged and frequent than it is in diphtheria. This subject may best be studied in connection with cases which carry home infection from the isolation hospital. The English data are much the most valuable for this purpose as the hospitalization of patients is carried further there than in other countries, and the subject has been more carefully studied. Three reports have been made concerning these "return outbreaks" of scarlet fever and diphtheria in the London hospitals, covering the years 1899 to 1904. The number of scarlet fever cases discharged from the hospitals during this period was 57,810, and the number of "infecting cases" i. e. cases which carried infection home from the hospital was 2,225, or 3.8 per cent. It has been argued that a good many of the apparent instances of "return infection" are merely coincidences, but Turner (8) has shown that this can be true of only a very small number. Turner has presented his facts in the form of diagrams which are well worth studying. These diagrams show the time distribution of the cases which develop after the return of the infecting case, and it appears highly improbable that more than a very few can be coincidences, or due to a lingering infection in members of the family remaining at home, or in the house itself. Such a large series of cases gives an excellent opportunity for studying the duration and mode of infection in this disease.

The following table taken from Cameron's (9) report shows the time of detention in certain hospitals of all cases of scarlet fever treated in them, and also the time of detention of the infecting cases, that is of the cases which carried the infection to their homes.

TABLE III.

(August, 1901, to July, 1902, inclusive.)

	Under 2 weeks.	-4	-6	-8	-10	-12	-14	-16	Over 16.	Total.
"Infecting Cases"...	....	3	41	209	210	112	34	24	20	653
Percentage.	....	.45	6.27	32.06	32.15	17.13	5.20	3.67	3.06	.....
								6.	73	.....
"All Cases"	15	88	975	5,070	4,667	2,258	1,222	12	06	15,501
Percentage.	.09	.56	6.28	32.70	30.10	14.56	7.88	7.	78	.....

This table shows that in 609 instances the infectivity was prolonged beyond 6 weeks, in 190 instances beyond 10 weeks, in 44 instances beyond 14 weeks and in 20 instances beyond 16 weeks. A similar prolongation of infection is also shown by the tabulation of the 1,085 infectious cases in Turner's (10) report which is shown on the following page:

TABLE IV.

Period of detention of infecting cases (primary Scarlet Fever only).

Detention in days.	1902.	1903.	1904.	Total.
14 to 20	2	.....	.....	2
21	3	2	1	6
28	4	11	4	19
35	18	18	13	49
42	82	57	41	180
49	96	62	58	216
56	83	48	44	175
63	68	45	26	139
70	46	30	13	89
77	35	25	11	71
84	14	16	7	37
91	11	13	14	38
98	2	7	4	13
105	10	4	3	17
112	3	5	3	11
119	1	2	4	7
126	3	2	.....	5
133	3	1	1	5
140	.....	.....	.....	.....
147	.....	1	.....	1
154	.....	.....	1	1
161	2	1	.....	3
168-175	.....	.....	1	1
Total	486	350	249	1,085
Period of detention uncertain, two or more infecting cases having been discharged after different periods of detention	16	20	11	47
Totals	502	370	260	1,132

The longest period noted by Turner was over 24 weeks. Instances of prolonged infectivity in scarlet fever may occasionally be found in medical literature. A number are reported by Newsholme (11). Other are given by Cameron (12) in one of which the infectivity

lasted over 16 weeks, or 10 weeks after discharge from the hospital. Zilgien (7) reports an instance where a girl probably remained infectious from July 6 until the following March. Simpson (13) gives several instances of prolonged infectivity, one of them extending over 240 days, or 8 months. Most of these cases of long standing infection have some discharge from nose or ear. I have seen a case of scarlet fever which was taken sick on June 25, and was discharged from the hospital on November 15, apparently giving rise to two other cases within a few days. This case had a discharge from the ear. Such very prolonged infectivity is apparently not very common. The 20 cases reported by Turner as lasting over 16 weeks were only 3 per cent of 653 infecting cases discharged from the hospital, and only 0.12 per cent of the whole 15,501, cases discharged.

It will also be seen from the tables that the patients who remain in the hospital from 8 to 12 weeks furnish the largest number of return cases. From this fact, as well as from other considerations, Simpson, as well as various other writers, have argued that infectivity is increased by prolonged residence in a hospital, because the patients absorb the scarlet fever virus, perhaps in more virulent form, from other patients in the ward. Both Cameron and Turner hold that this is probably not so. One reason why patients detained over 8 weeks are more likely to prove infective, is because

they are usually retained on account of some complication, which indicates a probably great virulence of the disease poison. Complicating discharge from nose and ear directly maintain infectivity. The figures also show that the longer these complicated cases are kept in the hospital, so that opportunity may be afforded for complete recovery, the fewer are the resulting return cases, which could not be if infectivity were caused by long residence in the hospital. That the duration of infection depends on the type of the disease, virulence of the virus, and the complications, and not on hospitalization is also urged by Newsholme. The heightened virulence of the infecting cases, is shown by the fact, as set forth by Cameron, (14) that the case fatality of the return cases caused by them is 5.8 as compared with 3.6 of all cases.

If cases are treated at home late recurrence of the disease is noted there also. Thus in Providence, after disinfection, there is a recurrence of the disease in the same families in about 1.2 per cent of the families, and in other families in the house in 2.4 per cent of the families. Disinfection is usually done at the fifth or sixth week. So also when well children are sent away from home they will sometimes contract the disease on their return, and as shown on page 15 the danger decreases rapidly. Of 1,671 susceptible persons mostly children so removed and returned after the termination

of isolation, usually about the fifth or sixth week, 31 or 1.2 per cent have been taken sick with the disease.

The tables show also, particularly those of Turner, that the cases discharged before 6 weeks have a lower infectivity than those discharged later. These early cases are mild and uncomplicated, and apparently lose their infecting power before the others.

Some are beginning to think that the period of isolation for scarlet fever has been unduly prolonged, at least in England, and, as will be shown later, the average period of detention in the hospital, has in several towns been materially reduced without causing any increase in the number of return cases. Barlow (16) thinks that many mild cases are infectious but a few days. Zilgien (17) agrees with Barlow and gives instances where isolation during the sore throat only, proved sufficient.

From a consideration of the facts here presented it appears that cases of scarlet fever are infectious from the very beginning, that the period of greatest infectivity is probably during the presence of the acute symptoms, sore throat, fever and rash, that it probably diminishes rather rapidly after the disappearance of these symptoms, and that by the end of four weeks has disappeared from all but a small percentage of the cases. That in some instances infectivity may persist for many weeks and even for several months.

SOURCES OF THE INFECTION IN THE BODY.

It is now necessary to consider the source of the virus in the human body in order that we may the better determine the conditions under which individual patients are infective.

The Throat. There is much reason for thinking that the specific poison of scarlet fever is contained in the secretions of the throat in the early stages of the disease, and perhaps it may persist there, in some at least, of the cases of long continued infection. The pathological process is most acute and marked in the throat, and the contagiousness of the disease is greatest during the acute stages and rapidly diminishes with the abatement of the throat symptoms. There are also a few direct observations which are in accord with this view. Jurgensen (15) says that Copland reports a case infected by the sputum in the early stages of the disease. Stickler (16) inoculated into 10 children mucus taken from the throat of a patient just after the rash appeared. Every child developed within from 12 to 72 hours a fair picture of scarlet fever. Grünbaum (17) reports a single instance of the possible infection of an ape with the secretion from the throat of a scarlet fever patient. Cameron (18) shows in the accompanying table that while morbid conditions of the throat, such as enlarged tonsils, and inflammation with excessive secretion, were reported from only 6.3

TABLE V.

(Period July 1901 to July 1902 inclusive).

Number of Cases.	Morbid Condition of Nose.			Morbid condition of the Throat.	Enlarged Gland.	Desquamation.	Affections of Skin and Scalp.	Otorrhoea.	Post Nasal discharge.	Cough.	Conjunctivitis.	Leucorrhoea Abscess Anal fissure.	Stomatitis.	Albuminuria.	No apparent morbid condition
	Purulent Rhinorrhoea.	Rhinitis.	Non-Purulent Rhinorrhoea.												
"Infecting Cases".....	121	121	96	209	145	94	94	54	23	17	9	253	4	1	125
Percentage	18.67	18.67	14.81	32.25	22.37	14.50	14.50	8.33	3.54	2.62	1.38	10 1.54	.61	.15	19.29
		52.31													
"All Cases".....		593		1,052	529	1,361	274	361	....	....	....	.....	....	68	12,860
Percentage		3.55		6.30	3.17	8.15	1.64	2.16	....	....	....	.....	....	.41	77.

per cent of the total scarlet fever cases discharged from the hospital, such conditions were associated with 32.25 per cent of the infecting cases. Scarlet fever *sine eruptione*, that is with the symptoms confined exclusively to the mucus surfaces, chiefly the throat, are reported by all writers on this disease. It is the infectivity of these cases which establishes the diagnosis, and the fact that they are infectious, though throat symptoms only are apparent, strengthens the conclusion that the throat is the seat of infection. Cameron (19) reports 104 cases of possible scarlet fever sore throats many of which proved infectious. A milk outbreak with many such cases is described by Newsholme (20).

In the Nose. In diphtheria the specific bacillus is found rather more often in the nose than in the throat, so we would expect that in scarlet fever, the nose as well as the throat, might be infected. Nasal discharge may be observed at any stage of the disease, but it is only in the later stages that its infectivity seems to be established. The middle ear trouble which is so frequent a complication of scarlet fever, is doubtless due to an extension of the pathological process from the naso-pharynx. A similar extension takes place in diphtheria, much more commonly than is usually stated. That some form of rhinitis, usually virulent, is frequently associated with prolonged infectivity, has been

noted by a number of English observers as Newsholme, Pugh, Niven, Lauder, Simpson, Cameron and Turner, and is well shown by Cameron's table shown on page 24. He shows that of the infecting cases discharged from the hospital 52.31 per cent had some form of rhinitis, while of the total cases only 3.55 per cent had this complication.

It is observed that nasal, and also aural discharge, in convalescent scarlet fever patients, is not continuous, but that often a number of days or weeks elapse in which there is no discharge. A renewal of the discharge from the nose is sometimes accompanied by a recrudesence of infectivity, shown by the patient transmitting the disease to another. Thus Cameron (21) reports a case which was discharged well from the hospital, but 22 days later a rhinitis developed, and another case in the family was taken sick in 5 days. Cameron gives a score or more of such cases.

Besides the fact that a persistent sore throat and an excessive nasal discharge are found to a considerable excess in infecting cases, and that recrudesence of these symptoms is followed by the development of fresh cases, evidence of the infective nature of these discharges is found in the decrease in the number of return cases where special care has been taken not to send home patients in which throat and nose symptoms are present. In many of the English hospitals less attention is being paid to desquamation and more

to the condition of the nose and pharynx. The result is that in London, Birmingham, Manchester, Southampton, Huddersfield, and other places the number of return cases is diminishing, and at the same time the period of detention in the hospital has been materially shortened.

The Ear. A discharging ear in a convalescent scarlet fever patient has long been believed to be infectious, and is still considered so by most observers. Cameron (22) thinks it is not proved that otorrhea is infectious, and he suspects that it is not. Of 123 patients with otorrhea, only 8 caused the infection of others, and in all of these there existed a concurrent rhinitis. Nevertheless he shows, p. 24, that while only 2.16 per cent of all discharged scarlet fever cases have otorrhea, at the time of discharge, 8.33 per cent of the infecting cases had it. Otorrhea frequently occurs in diphtheria, and I have repeatedly found the diphtheria bacillus in the discharge, as have others. We should expect also to find the discharge infectious in scarlet fever, and it does not appear on present evidence to be safe to consider it otherwise. An otorrhea may last a very long time, but the discharge is often very slight, and in many instances it is not necessary to isolate the patient if the ear is properly cared for, and perhaps kept plugged with cotton.

The Skin. From time immemorial the desquamating skin of scarlet has been considered not merely infectious, but even as the sole vehicle of infection. It is not surprising that this view should have arisen, for the desquamation of smallpox was demonstrated by inoculation to be infectious, and that of scarlet fever was by analogy assumed to be so. Desquamation persists a long time, as does the infectivity, and the two often disappear together. Formerly the air was believed to be the chief carrier of infection, and what could be more readily carried by the air than the light and fine epidermal scales? But of late years many have begun to question the infectivity of the exfoliated epidermis. Among these may be mentioned Boobbyer (23), Richards (24), Gilbert (25), Millard (26), Lauder (27), Cameron (28), Bond (29), Moore (30), Turner (31), and Lemoine (32).

It is recognized that the assumed analogy between scarlet fever and smallpox is a false one, and that scarlet fever quite closely resembles diphtheria. It seems probable that the pathological process is for the most part confined to the mucous surfaces, chiefly of the throat and nose, and that the exantham, and subsequent desquamation, are due to toxins elaborated for the most part in the throat. The a priori argument is against the infectiousness of the exfoliated skin. As for direct evidence of such infectiousness there is none. The burden of proof lies upon those who assert the

affirmative. On the other hand there is positive and strong evidence that desquamation is not always dangerous. There is a considerable mass of evidence, mostly from English hospital experience, which shows that in the discharge of scarlet fever cases, desquamation may be neglected. Priestly (33) during a small pox outbreak at Leicester discharged 120 scarlet fever patients who were desquamating, and no secondary cases developed in any of the homes. Lauder at Southampton (34) sent out 204 desquamating patients only 2 of which, 0.98 per cent, gave rise to secondary cases. One of these infecting cases also had nasal discharge. Of the 121 cases without desquamation discharged during the same period 5, or 4.13 per cent proved infective, all of which had some abnormal discharge from nose, throat, or ear. By paying particular attention to the mucous surfaces while neglecting desquamation, Lauder was able to reduce the percentage of return cases from 4.27 in 1902 to 2.15 in 1903, at the same time shortening the period of detention in the hospital from 48 to 34 days.

In certain of the London hospitals, 1902-4, no case was discharged while desquamating, and of 6,164 discharges, 246 or 3.99 per cent were followed by return cases. Of 12,000 cases discharged from hospitals where no attention was paid to desquamation, and many of which cases were desquamating, return cases developed 269 times, or 2.24 per cent. Undoubtedly the hos-

pitals which paid little attention to desquamation paid special attention to mucous discharges and hence the lower number of return cases.

Urine, Feces, Pus from Glands. There seems to be no evidence either for or against the infectiousness of these excretions.

Infectivity with No Apparent Pathological Condition. That convalescents from scarlet fever should carry the virus of the disease while exhibiting no symptoms or lesions, is not surprising. It is a phenomenon common to many diseases, and has been particularly studied in diphtheria and typhoid fever. The "carrier case" is coming to be recognized as a most important, if not the most important, factor in the spread of these two diseases. As the specific germ of scarlet fever is unknown, the evidence of the existence of "carriers" of scarlet fever is not so conclusive or abundant as for diphtheria and typhoid fever. Yet there is little doubt that many persons are infected with scarlet fever and capable of giving the disease to others, and yet present no symptoms whatever of disease. Thus 125 of the infecting cases discharged from the London hospitals and investigated by Cameron (18) showed no apparent abnormal condition. Millard (35) showed that 58.2 per cent of the infecting cases at Birmingham were quite clear in every way, and Boobbyer states that 11 of 26 infecting cases at Nottingham were free

from symptoms of disease. I have kept no record of the condition of the infecting cases observed by me, whether discharged from the hospital, or remaining in their homes, but it may be definitely stated that very many of these showed no discharge from nose or ear, no sore throat, no desquamation, and in fact no other symptoms of the disease. Cameron reports 30 instances, and Turner 44, in which diphtheria patients carried scarlet fever from the hospital to their homes. The presence of scarlet fever infection in these cases had not been indicated by any physical signs. There is a good deal of evidence that perfectly well persons, who have never had scarlet fever, may nevertheless carry the poison in their persons and transmit it to others, but in the absence of bacteriological evidence we have no means of knowing how long such infection may last.

MODES OF INFECTION.

Before proceeding to consider the different modes of infection in scarlet fever we may inquire what is known as to the degree of contagiousness of this disease. I have prepared the following table to show its infectivity in families in which the patient lives and is kept at home during the whole course of the disease.

TABLE VI. SCARLET FEVER.

Cases from families in which the patient lived and remained at home during the whole illness.

Age and Sex of Primary and Secondary Cases.

	Primary Cases.						Secondary Cases.					
Ages.	M.	Attack Rates.	F.	Attack Rates.	Total M. & F.	Attack Rates.	M.	Attack Rates.	F.	Attack Rates.	Total M. & F.	Attack Rates.
Under 1 yr.	15	10.9	6	4.3	21	7.6	6	4.9	7	5.2	13	5.1
1.....	28	22.0	30	22.6	58	22.3	16	16.2	24	23.3	40	19.8
2.....	61	35.1	55	39.6	116	37.1	32	28.3	17	20.2	49	24.9
3.....	66	39.1	83	45.9	149	42.6	40	38.8	21	21.4	61	30.3
4.....	75	39.1	69	39.4	144	39.6	41	36.3	37	34.9	78	35.6
5.....	74	38.5	77	45.0	151	41.6	37	31.4	31	33.0	68	32.1
6.....	83	45.8	91	45.5	174	45.7	30	30.6	32	29.3	62	30.0
7.....	69	43.9	84	45.2	153	44.6	22	25.0	30	29.4	52	27.4
8.....	62	40.8	86	47.5	148	44.4	28	31.1	30	31.6	58	31.4
9.....	52	40.0	75	43.9	127	42.2	12	15.4	24	25.0	36	20.7
10.....	42	29.4	54	38.6	96	33.9	18	17.8	18	20.9	36	19.3
11.....	32	25.8	48	39.7	80	32.7	8	8.7	16	21.9	24	14.5
12.....	21	20.4	36	33.3	57	27.0	13	15.9	16	22.2	29	18.8
13.....	11	15.9	25	25.3	36	21.4	6	10.3	5	6.8	11	8.3
14.....	24	26.7	22	26.2	46	26.4	2	3.0	10	16.1	12	9.4
15.....	11	15.7	15	19.5	26	17.7	3	5.1	9	14.5	12	9.9
16.....	10	13.0	10	14.9	20	13.9	2	3.0	6	10.5	8	6.5
17.....	7	10.2	6	11.3	13	10.7	5	8.1	2	4.3	7	6.4
18.....	5	8.8	8	13.6	13	11.2	2	3.8	3	5.9	5	4.8
19.....	5	9.6	5	9.8	10	9.5	2	4.3	2	4.2	4	4.2
20.....	3	6.8	3	7.0	6	6.9	0	.0	2	5.0	2	2.5
A.....	56	3.1	63	3.1	119	3.1	13	.7	34	1.7	47	1.3
Totals.....	812	18.8	951	20.7	1,763	19.8	338	9.6	376	10.3	714	10.0

While it is most important to know to what degree scarlet fever may be expected to spread through the family, it is of more importance from an epidemiological point of view to know what the chance is of its spreading from family to family, and in schools and similar places. Instances are not rare where children presumably in the infectious stage of scarlet fever, have mingled freely with others for many days, or perhaps weeks, with little or no extension of the disease. I have notes of an instance where a boy with scarlet fever in the sore throat stage, attended a Sunday School festival, and no other case developed among the large number of children present. At an infant asylum a child was sick with mild scarlet fever for 17 days, mingling freely with about 75 children, mostly under 5 years of age, and only 3 other cases resulted. At a large school, a girl returned at the end of the first week of an attack of scarlet fever, and continued her attendance for 20 days. Only 3 or 4 cases developed in that school. Similar and even more marked instances of apparently feeble infectivity are reported by others, and the same phenomenon has been noted in smallpox and diphtheria. In the latter disease bacteriology has shown us that it is quite common for "carriers" to mingle freely with others without spreading the disease. I have known of a teacher with virulent diphtheria bacilli in her throat from the

first of January to the middle of April, who taught in a kindergarten all that time, but who did not transmit the disease to any one. Hence we should not be surprised to find that scarlet fever, except under conditions of the closest contact, does not show a very high degree of contagiousness.

In Providence most people live in tenement houses with one or more other families, and the amount of infection of second families in the house, and the conditions under which this takes place is of much epidemiological interest. I have records of such an extension of the disease for a number of years. Of 4033 other families living in the same house with the family first attacked, and using the same doors and passageways, 291 or 7.2 per cent have been invaded. This is a surprisingly small percentage, when it is remembered that most of the families are poor, or at least in moderate circumstances, and that the houses are frequently very much crowded, and the people often ignorant and careless. Observation has shown that a large part of the infection takes place before the disease is recognized, and while there is a free mingling of the children and perhaps other members of the families, and a certain other part of the cases are due to a mingling after the termination of isolation, when it is supposed that the infective stage is passed. But as we have seen the infective stage in a small percentage of cases continues unrecognized, and often un-

recognizable for a long time. The time at which infection of second families takes place is shown by the table on page 13 which, however, only covers the five years during which these special data have been tabulated. Of 80 families which developed the disease while the warning sign was on the house 54 were during the first two weeks of the initial sickness. Most of these cases probably contracted the disease before the house was placarded. From the end of the second week of the disease in the first family to the end of the second month, there were only 24 instances in which there was extension of the disease from one family to another in the same house. This is only 1.3 per cent of the 1,888 families exposed.

It appears then that scarlet fever almost never extends from one family to another in the same house, except when there is free communication between the members, usually before the disease is recognized, more rarely after the termination of isolation, and more rarely still while the warning sign is upon the house. This happens in houses where two, and perhaps four or six families, use the same hallways, doors, cellars and perhaps the same water closets. The woodwork in these houses is rarely cleaned, and the children and grown people in the infected family, even the mother who nurses the patient, are constantly running their hands up and down the stair-rail, along the walls, and are opening and closing the doors. The

mother will carry slops to the cellar, and the garbage and refuse to the yard. That the disease does not spread under these conditions throws light on the degree of infectivity and the mode of infection in this disease.

Among the modes of infection worthy of consideration are the following:

Infection by Contact. This is the most obvious means by which the extension of the disease may take place. The term is coming into quite general use but is not accurately defined. In this connection it means the quite direct transference, of quite fresh infective material. The transference may be immediate, as in kissing, or far more often, mediate, as by two persons drinking from the same glass, or moistening the same pencil in the mouth. There are a thousand and one ways in which young children thus transfer the secretions of the mouth and nose from one to another. They are constantly putting their fingers and every imaginable article, into the mouth, or are boring the nose with the fingers. Toys, cups, spoons, pencils, candy, food, string and countless other things, may thus easily become the bearers of the secretions from child to child, and there is often likely to be an even more direct transfer as they romp and tumble over each other in play. The opportunities for such contact infection in the family are so numerous and constant that the won-

der is not that infection takes place, but that half of the children of even the most susceptible age escape during the month or six weeks' presence of scarlet fever. It is not improbable that apparent differences in age and sex "susceptibility" to the disease, may be largely an expression of the chance for contact with the patient. Infants are less susceptible perhaps because they do not mingle freely with and play with other children. The years of greatest susceptibility, from two to ten are exactly those years in which children are careless and have little idea of cleanliness, and are constantly coming into the closest possible contact with one another. A noticeable feature of family infection is that women over 16 years of age are more than twice as likely to contract scarlet fever when it has once invaded the family, than are men of the same ages, a fact to be explained perhaps by the women coming into far more intimate personal contact with the patient than do the men. The constant escape from the disease of the vast majority of other families in the same house, speaks for the necessity of quite close contact to insure infection. This view that contact infection is the chief mode of transference of scarlet fever is coming to be recognized by many of the most careful observers, especially in England and France. Thus Cameron (12) gives several instances in which the development of return cases did not take place as long as the infecting case did not come into

immediate contact with susceptible members of the family. Niven in Manchester from a study of return cases in that city is convinced that if the children can be kept slightly apart in the family, there is no transference of the disease. That there is much good evidence that scarlet fever does not spread in the absence of contact will be shown when considering the possibility of infection by air.

Doubtless the chief reason for scepticism as to the sufficiency of contact infection to account for the extension of scarlet fever, is the fact that in a large proportion of cases it is impossible to find any connection with a previous case. If there is no change for contact infection from another case, it seems to be necessary to discover some other and more circuitous, or less visible, mode of transference. This point of view depends upon the assumption that all or nearly all persons infected with scarlet fever are recognized as such. This assumption at the present day is entirely unwarranted. It is now well known that in many of the infectious diseases, atypical forms, not easily recognized clinically and frequently not seen by a physician. are very numerous, perhaps more numerous than are the cases seen and recognized by medical men. This is noticeably true of diphtheria, typhoid fever and yellow fever. It has also, within a few years, been learned, what was never before suspected, that in many diseases an even larger number of persons are the "carriers"

of disease germs without exhibiting any symptoms of disease. This has been proved true of diphtheria, typhoid fever, malaria and particularly of cerebro-spinal-meningitis.

Unfortunately the laboratory cannot as yet help us in finding the "missed cases" and "carriers" of scarlet fever. But all who have made a careful study of this disease know that there are very frequently seen cases with a scarcely discernible indefinite rash, lasting for only a few hours, a rise in temperature of only a degree or two, lasting also only a few hours, and the merest trace of sore throat. Sometimes the rash may be entirely absent. In institutions and families, such cases, considered doubtful at first, or perhaps neglected, prove to be the origin of typical symptoms in others. They are the missed cases which are such a factor in the maintenance of this disease. There are many references to them in the reports of health officers and in medical literature. Among others who report such atypical cases are Newsholme (11), Gaziot (36), Welch and Shamberg (37), and Cameron (38). In most of these "missed" cases there were some slight symptoms, but overlooked or misunderstood at the time. In Manchester in 1906 there were discovered 229 missed cases, mostly of a mild character. From these 139 other cases had developed (39). True "carriers," that is perfectly well persons, are sometimes reported. Thus I saw an instance where a woman apparently so carried scarlet

fever to her child. She had been taking care of another child, and after an entire change of clothing, bath and shampoo, visited the first named child who was taken sick two days later. Newsholme reports what he thinks are possibly, or even probably, similar cases. Newman (40), of Finsbury, (London) noted five carriers among school children, three of whom, though they had never had the disease, transmitted it to others. Cameron (41) reports many such cases. While the proof of the number of carriers and missed cases is not so conclusive as it is for diphtheria and typhoid fever, and never can be in the absence of laboratory evidence, it is yet sufficient to warrant the belief that the unrecognized sources of infection are numerous enough to permit the origin from them by contact infection of all the recognized cases of the disease.

Infection by Fomites. Whenever in the past it was impossible to trace any direct connection between cases of scarlet fever, indirect means of communication were sought for, and it was not infrequently found that a toy, book, clothing, or some other material thing, which had previously been used by one scarlet fever patient, was used by another case a short time before the development of the disease. These supposed bearers of infection are called fomites, and it has been alleged that they can retain their virulence for many

weeks, months and even years. It is seen that the distinction between immediate contact and fomites infection is not a sharp one. The common usage is to apply the term contact infection when the interval in time is short, perhaps a few hours, often only a few minutes, and to use the word fomites when the interval is long. In contact infection the infective material is moist, or at least not dry, in the case of fomites, we commonly think of the infective material as pretty well dried.

It is unnecessary to give instances of alleged fomites infection in this disease. They are found scattered through medical literature in almost every article and text book dealing with scarlet fever. In many of them the disease is traced to an infected schoolroom or house, or to clothing, books or toys which have been carried long distances. Often no mention is made of the occupants of the room, or the bearers of the goods, who are much more likely to have been the "carriers" of living germs, than the things were to bear even dead germs, a fact which is rarely recognized by the narrators. Often no pretence is made to exclude other sources of infection, and in most instances there is merely a possibility and not even a probability, that the fomites were really the source of the disease. The utter destruction by Reed, of the implicit confidence formerly placed in the role played by fomites in the spread of yellow fever, should make us wary of admit-

ting the much less convincing proofs of fomites infection in scarlet fever. Diphtheria also has long been considered a fomites borne disease, but the entire abandonment of disinfection after that disease, in Providence (42) has not resulted in any increase in the number of cases. There is certainly no stronger evidence of infection by fomites in scarlet fever than there was for diphtheria. Lemoine (43) has shown that in the military hospital at Val de Grace it was possible to put a considerable number of persons in a ward just cleared of scarlet fever patients and with no disinfection, and yet without any one contracting the disease. At a recent conference (43) in Paris, Courmont, Comby and others affirmed that the very thorough disinfection of goods and houses carried on by the sanitary authorities of that city is unnecessary, and has no effect in diminishing the spread of scarlet fever, diphtheria or measles. In England it has been claimed by some that the alleged "return cases" of scarlet fever are not so often due to the return of the patient, as to failure of disinfection, but Cameron (44) has shown that this cannot be true, for the cases are associated chiefly with patients of certain ages, and particularly with those suffering from complications.

Perhaps the best evidence that infection by fomites is not easy, is found in the fact previously referred to, that there is so little extension of the disease in tenement houses. If the mothers, fathers, brothers and

sisters, of the patient, do not infect the hallways, stair rails, doors and water closets so as to cause the disease in the other inmates of the house, can there be any appreciable danger of their carrying the virus in their clothes to their work or play?

It will not be denied that infection by fomites may not take place in scarlet fever, nor that there may be some instances of long persisting infectivity by fomites. But it is affirmed that there is no evidence that such a mode of infection plays any appreciable part in the extension of the disease, and there is much evidence that it does not.

Infection by Air. Another explanation of the source of scarlet fever which cannot be traced to direct contact with another case, is that the infection is airborne. This idea of the importance of airborne infection depends very largely on the belief that the desquamating epidermis is infectious, a belief for which it has been shown there is no evidence. The writer like every health officer, has frequently noted that a case of this disease may remain in school or hospital ward for days, or sometimes for weeks, without another case developing, or at most only one or two cases. Such facts indicate that the disease is not easily airborne. Visitors to fever hospitals do not contract scarlet fever. Thus of 300 to 400 non-immune students who visited the scarlet fever wards of

the Philadelphia hospital, remaining in the ward from twenty minutes to an hour, not one contracted the disease (45). Oftentimes scarlet fever does attack other patients in hospitals but it is in a manner to indicate contact rather than airborne infection. When contact infection is rigidly guarded against as in the Pasteur Hospital in Paris, scarlet fever may be and is treated in the same ward with other diseases without cross infection.

Attention has already been called to the comparative rarity with which scarlet fever passes from one family to another in the same house, and I have shown that when it does so occur it is almost always due to free communication between the families, that is to contact infection. Notwithstanding the fact that the doors of tenements are frequently opposite one another and that during a considerable part of the year the doors and windows are wide open, infection by the air does not take place.

If scarlet fever is not airborne from family to family in the house, one would not expect it to be borne from house to house by the air. Yet such a claim is sometimes made, that the virus of the disease may thus be transmitted a considerable distance. A number of the reports of the health department of Philadelphia contain shaded maps to show the greater prevalence of this disease, as well as of smallpox, in those parts of the city near the hospital. I do not think that

much value attaches to such maps for there are too many factors involved, and very rarely is the intensity of the disease as great close to the hospital as the theory demands. Moreover around very many hospitals no such distribution of the disease can be shown. Thus Tarnissier (46) in Paris found that Enfantes Malades and Trousseau hospitals could not be considered foci of infection. The same is true of the scarlet fever wards in Providence, in Detroit, and in Boston. In the latter city (47) for the period studied there were no cases of the disease within one eighth of a mile of the hospital, while in the next eighth of a mile circle there were 68 cases, in the next 71, in the next 75, and in the next 72.

Where various contagious diseases are treated in different wards of the same hospital there is sometimes cross infection. But this occurs so irregularly as to time and place, and is so limited in amount that it can scarcely be attributed to anything but contact infection. As most of the physicians and nurses in our contagious hospitals have no appreciation of what true medical asepsis really means, it is surprising that we see as little cross infection as we do.

Perhaps the best evidence we have that scarlet fever is not airborne is that furnished by the Pasteur Hospital in Paris. In this hospital, patients with different diseases are cared for in separate rooms opening out of a common corridor. If air infection is dangerous

anywhere it ought to be under these conditions. Between October 1, 1900, when the hospital was opened, and April 19, 1903, 2,000 patients were received, of whom 92 had scarlet fever, but in no instance did any one in the hospital contract this disease (48).

There is no direct bacteriological evidence bearing on the question of the ærial convection of the scarlet fever virus. Yet bacteriology does offer some suggestions. As the skin is probably not infectious, we must look to the mucous surfaces for the source of our airborne infection, but the laboratory has shown us that bacteria and other solid particles are not thrown off from moist surfaces, but are rather entangled in them. The only way that infection can pass from throat or nose, is by means of the little droplets which are thrown off in coughing, sneezing, and even in talking. It has been shown that usually the droplets which are large enough to infect, speedily sink, so that droplet infection will rarely take place over a yard from the patient. Droplet infection at short distances is doubtless possible in scarlet fever, and in this sense it is an airborne disease. But for all practical purposes droplet infection more nearly resembles contact infection than it does aerial infection as the latter is generally understood.

Infection by Milk. It has long been known that milk may be the means of spreading the virus of scar-

let fever, and a considerable number of outbreaks of the disease have been traced to this source. A federal report issued in 1908 (49), notes 51 such outbreaks, but doubtless others have been reported which were not included in this enumeration. This seems like a serious indictment of milk, but when it is taken in connection with the vast number of cases of scarlet fever that have occurred in Europe and America during the last thirty or forty years, it will appear that milk infection is not after all a very important factor in the spread of this disease. Milk outbreaks of scarlet fever, like milk outbreaks of other diseases, are characterized by a sudden onset, and the occurrence of a large number of cases within a brief period. As the incubation of scarlet fever is short, and the infection of the milk is usually temporary, the cases are often massed in a period of a few days only. Thus of the 717 cases in the milk outbreak in Boston in 1907 (50), 485 occurred within 6 days. The exceptionally explosive character of these outbreaks renders it likely that few escape notice, yet it appears that they are quite rarely reported. Only one has come to the notice of the writer during an experience of many years. In this outbreak there were 26 cases, a very small part of the 13,001 cases which have come under his observation.

It matters little for our present purpose, how the milk becomes infected. It has been claimed by some that cows may have scarlet fever and infect the milk

directly. Klein at one time strongly urged this source, and thought that he had found in the cows the streptococcus or diplococcus which he believed was the cause of the disease. But his observations have not been verified, and it is generally believed at the present time that milk receives scarlet fever infection from human sources exclusively.

While it is certain that occasionally extensive and spectacular outbreaks of scarlet fever are caused by infected milk, and that every effort should be made to prevent such milk infection, it is equally certain that milk infection plays but an infinitesimal part in the epidemiology of scarlet fever.

SUMMARY.

1. The micro-organism which presumably is the cause of scarlet fever is unknown.

2. Evidence points to scarlet fever as a local disease of the throat and nose, as is diphtheria.

3. The rash and desquamation are more likely to be due to the action of a toxin than to the presence of the pathogenic organism in the skin.

4. The incubation, or more properly latent period, of scarlet fever is usually short, but may be prolonged for weeks.

5. Scarlet fever is infectious with the appearance of the first symptoms. The height of the infectivity is coincident with activity of the throat symptoms. It then rapidly declines. In a small proportion of cases it may persist for months.

6. Prolonged infectivity is often associated with the persistence of the pathologic process in throat, nose and ear.

7. The secretions of the throat and nose are probably the chief source of infection.

8. The exfoliated epidermis is probably not infectious.

9. The infectivity of the disease is less than is generally believed.

10. In the great majority of cases scarlet fever extends by contact infection.

11. Infection by fomites is of little importance.

12. Except by droplet infection, which has a very limited range, scarlet fever is probably almost never an airborne disease.

13. Milk infection though a real danger, is the source of comparatively few cases.

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